

# Evoked taste thresholds in a normal population and the application of electrogustometry to trigeminal nerve disease

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**SUMMARY** No standardised method for taste threshold measurement is available and therefore comparison between clinical studies is difficult. An electrogustometer was evaluated in normal subjects. No sex difference in taste threshold was noted; however, there was a significant elevation in detection threshold with age and smoking. Electrogustometric values both in patients before and after surgery for trigeminal neuralgia and in patients with trigeminal sensory neuropathy were determined. Many patients with trigeminal nerve disorders had abnormal electrogustometric detection thresholds suggesting that there is possibly an accessory taste pathway through the trigeminal nerve, although in some individuals the site of lesion may be in the brain stem. Electrogustometry is a convenient method for clinically assessing taste.

Electrical taste was first documented by Sultzer<sup>1</sup> who in 1754 described a taste like ferro-sulphate when two different metals in contact with each other were placed on the tongue. Skouby<sup>2</sup> produced the first electrogustometer: this was tested on four medical students to demonstrate an alteration in taste threshold after various chemicals were placed on the tongue. Krarup<sup>3</sup> constructed an apparatus for electrical taste stimulation which he felt would be more suitable for clinical application. This electrogustometer was compared with semi quantitative investigations using taste solutions and found to give reproducible numerical results. However, because of complexity and limitations in size this was not widely adopted as a clinical tool. Over the past two decades, various modifications have been made concerning the design of electrogustometers, materials used for electrodes together with size and site of their placement.<sup>4</sup>

Recently there has been renewed interest in taste and its relationship to age,<sup>5-8</sup> obesity<sup>9</sup> and disease.<sup>10-14</sup> However, as a variety of different techniques have been used for this, their comparison is difficult and clinical application limited. Therefore,

there is a need to develop a standardised test to assess taste.

A reliable standardised electrogustometer for use in the clinical situation is here described. The underlying concepts and theory are based on the work of Krarup.

Taste depends on the stimulation of receptors within the taste bud by ions and molecules. Taste buds consist of five cell types. Type I cells are tall columnar supporting cells located in the basal portion of the taste bud. Type II cells are thinner and extend from the basal lamina to the cell pore where they may be seen as "taste hairs". Non-myelinated nerve fibres are in close contact to the basal cell layers. Type III cells are columnar and similar to type II but have differences in the basal portion with synapse-like vesicles. These cells together with type II cells are thought to be the principal sensory elements. Type IV cells are small and poorly differentiated and type V are crescent shaped and located at the periphery of the taste bud. All cell types stem from basal cells and continuous regeneration and differentiation takes place.<sup>15</sup> The average life span of the taste bud is 10 days. The density of taste receptors varies from one part of the tongue to another,<sup>16</sup> however they are most evident on the fungiform papillae on the anterior two-thirds of the tongue. Initially it was felt that each fungiform papilla reacted to only one of the

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four basic tastes<sup>17</sup> but a more recent study suggests multiple sensitivity in single fungiform papillae and in single taste buds.<sup>18</sup> This is inconsistent with the classical concept of four discrete tastes with differing receptor sites in the taste buds.

Any lesion involving the chorda tympani or nervus intermedius may result in diminution or complete loss of taste. There have also been some reports of ageusia occurring with disorders of the trigeminal nerve.<sup>19-21</sup> In these cases a diminution or loss of taste was noted in around 10% of cases following alcohol injection of the gasserian ganglion and possibly as many as 85% of cases following a middle cranial fossa surgical approach for trigeminal root section. It is uncertain whether loss of taste was due to damage to an alternative taste pathway travelling with the trigeminal nerve or to damage to the conventional taste pathways as a complication of the operation. Improved anaesthetic, radiological and surgical techniques have made operations for trigeminal neuralgia more precise and less traumatic.

The purpose of the present investigation is to establish data for a normal population in order to permit comparison with disease states in further studies. In order to explore the possibility of an alternative or accessory taste pathway, patients with trigeminal neuralgia before and after surgical treatment, and

patients with trigeminal sensory neuropathy were assessed by both chemical and electrogustometric techniques to determine any alteration of taste threshold.

## Methods

### The electrogustometer

This circuit diagram of the unit is shown in fig 1. A programmable current source (IC1) is used to set the current flowing through the patient which in turn is measured by the digital volt meter (RS Components 258-041). The current level is determined by the values of the resistors R1, R2, and R3. Resistor R1 is fixed and determines the maximum current level (approximately 1.4 mA). The two variable resistors R2 and R3 allow the current level to be adjusted by the operator.

The unit can operate in two modes determined by the switch S1. In one mode, when the circuit is complete, the current is flowing continuously. In the cyclic mode the current is switched on and off by the relay which is in turn controlled by the 556 dual timer integrated circuit; the on and off periods range from approximately 1 ms to 5 s, being controlled by the resistors R4 and R5. When the current was "on", a green light appears on the control panel and when "off", a red light appears. The frequency of stimulation can be adjusted by the control on the side of the casing. Current is altered by coarse (c) and fine (f) controls on the instrument panel (fig 2).

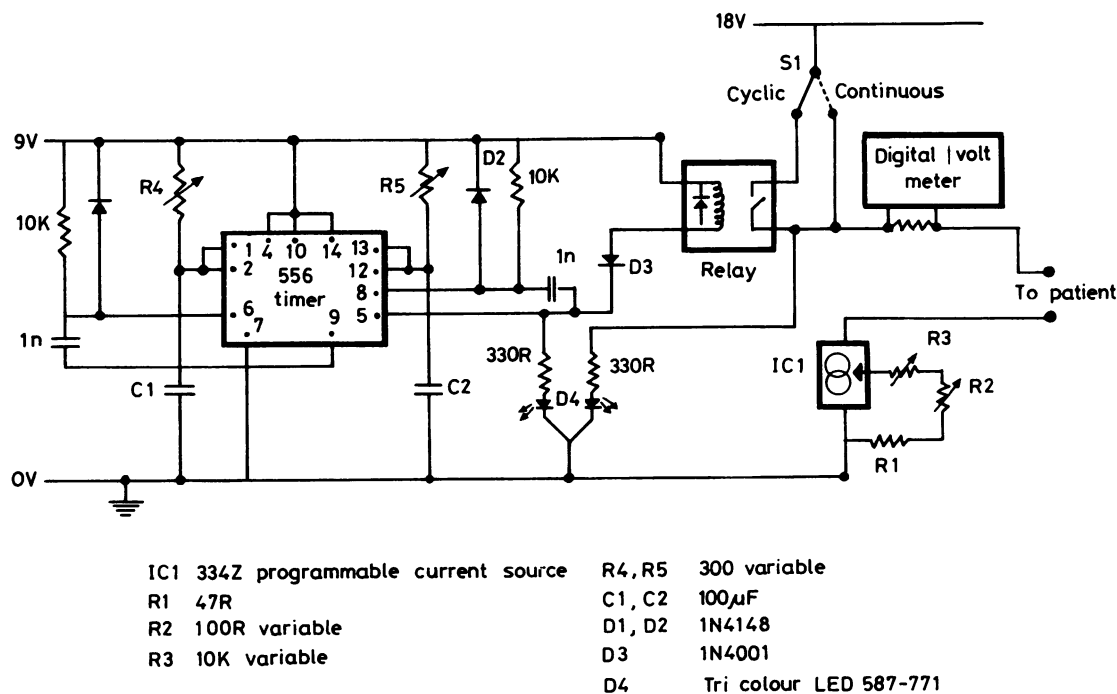


Fig 1 Circuit diagram of the electrogustometer.

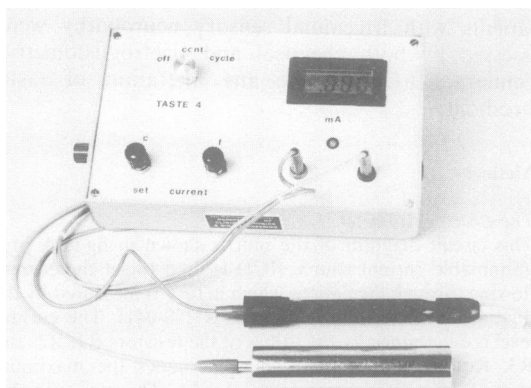


Fig 2 The electrogustometer. On-Off dial with continuous and cyclic modes. C = Coarse Adjustment Control, F = Fine Adjustment Control. Digital Display recording. Dial on left side of panel controls the frequency of stimulation while in the cyclic mode and bulb indicates when current is on. Upper electrode is the "active" electrode. Lower electrode is the "hand held" electrode.

In the preliminary testing of the electrogustometer two types of material were assessed for the active electrode in five subjects, namely carbon and stainless steel, in order to exclude the possibility of metallic ions contributing to the taste experienced. The contact area of the active electrode measured 60 mm<sup>2</sup> and a plastic insulating sleeve surrounded the shank of the electrode. Anodal and cathodal taste were studied. Thresholds on the anterior two-thirds and posterior third were compared in ten subjects.

Four subjects who could recognise the sour taste of anodal current were studied to investigate the effect of varying the frequency of a set alternating current (50  $\mu$ A) on taste threshold between 10 Hz–300 Hz. Electrogustometric detection thresholds were repeated after an interval of one week in 20 subjects to assess the reproducibility of recordings.

#### NORMAL SUBJECTS

One hundred and seventy-five subjects were studied. There were 76 males and 99 females. Ages ranged from 5 to 78 years, with a median of 39 years. Subjects had to be alert and orientated, to have no subjective disturbance of taste and were excluded if they had a history of any of the following disorders: local tongue disease (eg glossitis, lichen planus, geographic tongue), ear disease or deafness, neurological disorders such as Bell's palsy, multiple sclerosis or Parkinson's disease, endocrine or nutritional disorders, recent viral infections (within four weeks), oral or inhaled drugs, alcohol 24 hours prior to testing, food 1 hour or cigarettes 30 minutes prior to testing.

Age, sex, smoking habit and electrogustometric readings on right and left sides of the tongue were recorded.

#### Technique

The study was performed with the informed consent of the subjects or their parents, and the approval of the Research

Ethics Committee of the Institute of Neurological Sciences. The procedure was explained and the subjects asked to indicate when aware of any taste. The cathode was hand held by the subject and the anode was placed by the operator on the lateral border approximately 1.5 cm from the tip. The electrode was applied and positioned while the electrogustometer was off. It was then switched to continuous current and increased till a definite taste was evoked. When the subject indicated a taste the current was turned down and switched to "cycle". The current would continue for 5 seconds and then stop for 5 seconds. The subject was unaware when the stimuli would present and this made the test more objective. Using the fine control, current was increased slowly until the subject was able to identify a taste on at least three out of four occasions. The reading was then recorded. Thus taste detection threshold was determined by the "staircase" modification of methods of limits,<sup>22</sup> which is thought to give the most efficient measure of taste detection threshold.<sup>23</sup>

#### pH + current

In order to investigate the mechanism whereby taste was experienced at the active electrode, a system was constructed in which both electrogustometer electrodes were placed in a 0.01 M potassium chloride solution at 20°C. The active electrode was placed in close proximity to a pH micro-electrode. Current was then switched on and increased stepwise. pH was recorded at the active electrode using anodal and then cathodal current.

#### PATIENT STUDY

Taste was tested chemically by four standard solutions; sodium chloride (2.5%, 7.5% and 15%), citric acid (1%, 5%, 10%), saccharin (1%, 10%, 40%) and quinine hydrochloride (0.075%, 0.5%, 1%). Two drops (0.05 ml) of solution were carefully placed on one side of the anterior part of the protruded tongue using a pipette. The patient indicating the recognised flavour by pointing to written headings of sweet, salt, sour, bitter or "don't know". The mouth was rinsed with tap water between test substances, and sufficient time elapsed between each test substance to allow the previous taste to subside. Drops were applied from the most dilute to the most concentrated taste solutions. Bitter taste was tested last on each occasion as it tended to leave a prolonged aftertaste.

Formal chemical tests for taste and electrogustometry were performed before and after operation in patients undergoing surgery. Most patients were on a combination of drugs such as anticonvulsants, analgesics or medication for hypertension and/or heart failure. Sense of smell was tested in all cases using peppermint oil, Clearsol disinfectant 1:100, eucalyptus oil and lemon oil, as anosmia may be misinterpreted by the patient as diminished taste.

#### Group A

Twenty patients with a clinical diagnosis of trigeminal neuralgia refractory to medical therapy were studied. These patients were separated into two groups—"idiopathic" and "symptomatic of multiple sclerosis". In all cases, skull radiographs with petrous temporal views and CT scans with posterior fossa cuts were normal prior to eventual surgical procedure. Of the seven patients with multiple sclerosis all

but one were regarded as clinically "definite";<sup>24</sup> the single case fell into the "possible" category. All had abnormal visual evoked responses (VERs) and/or the presence of oligoclonal bands in the CSF.

Four types of operation were performed for relief of trigeminal neuralgia:

- (a) Trigeminal glycerol injection (n = 12)
- (b) Trigeminal nerve thermocoagulation (n = 3)
- (c) Posterior fossa exploration and microvascular decompression of aberrant vessels (n = 3)
- (d) Posterior fossa exploration and partial trigeminal rhizotomy (n = 2).

(a) *Trigeminal Glycerol Injection* After infiltration of the cheek area with 1% lignocaine and under the guidance of image intensification, a No 20 lumbar puncture needle was progressively passed towards and then through the foramen ovale. Papaveretum, in a dose of 5–20 mg, was given intravenously during this particular part of the procedure. A water soluble contrast medium, 0.1 ml iopamidol (Niopam 300—E Merck Ltd) was then injected through the needle to outline the trigeminal cave. The patient was tilted head down in order to remove all the contrast medium from the trigeminal cave, and then brought into the sitting position. Glycerol, 0.1 ml was injected into the cave from which CSF had been aspirated. At this time, pain was often referred to the site of trigeminal neuralgia and further aliquots of glycerol were injected in 0.1 ml increments up to a maximum of 0.4 ml. The patient was maintained in a sitting position with the head tilted forward.

(b) *Thermocoagulation* After infiltration of the cheek with 1% lignocaine a probe (Radionics) was passed towards the foramen ovale, with the image intensifier to aid localisation. The position of the probe tip was adjusted until electrical stimulation at 75 Hz and at low power produced a tingling sensation in the trigger area. Coagulation was then undertaken.

(c) *Microvascular decompression for trigeminal neuralgia* Under general anaesthesia, a small craniectomy through the squamous occipital bone was made to display the lateral part of the lateral sinus and upper part of the sigmoid sinus. Under visualisation with the operating microscope the dura was opened along the supralateral margin of the cerebellum towards the cerebello-pontine angle region. The trigeminal nerve was displayed and inspected for vascular compression. If there was any evidence of this a portion of sponge was placed between the nerve and the compressing vessel.

(d) *Posterior fossa approach with partial rhizotomy of trigeminal nerve* Surgical approach was similar to microvascular decompression but in the two cases where no vessel was seen compressing the trigeminal nerve, partial rhizotomy was carried out at the point where the sensory branch of the trigeminal nerve entered the pons.

#### Group B

Trigeminal sensory neuropathy is defined as a gradual spreading numbness which progressively involves one or more divisions of the trigeminal nerve. The motor branch of the fifth nerve is not involved.

Taste of five patients with trigeminal neuropathy was studied by chemical and electrogustometric means. Skull radiograph and CT brain scan with posterior fossa cuts excluded any detectable space occupying lesion involving the

trigeminal nerve. Magnetic resonance imaging was performed in two patients and was normal in both. There was no history of trauma, connective tissue disorders or demyelination. One patient (RD) also complained of unsteadiness and dysaesthesia in her feet but without clinical or electrophysiological evidence of generalised neuropathy or central nervous system involvement. CSF, however, did reveal elevated IgG:albumin index and an increased IgG percentage of total protein but without oligoclonal bands. Analysis of CSF in the other cases was normal. Rheumatoid factor and ANF were normal in all cases. There was no past history of local tongue disease, ear disease or other significant neurological cause for ageusia.

#### Results

Similar tastes and thresholds were obtained with both the carbon and the stainless steel electrodes. The latter was more robust and easier to clean; therefore further experiments were performed with this material as the active electrode. The threshold for cathodal taste was somewhat higher than for anodal taste, and taste threshold on the posterior third of the tongue was approximately ten times that on the anterior two-thirds. No response could be elicited in any other part of the oral mucosa even with maximal (0.14 mA) stimulation. Subjects were able to differentiate between the sour taste of the anodal current and the bitter/soapy taste of the cathode.

The subjects tested with alternating current at different frequencies of current described a taste between 10–50 Hz which was different from that at either the anode or cathode using direct current. However, this taste became less distinct between 50–100 Hz, and almost impossible to recognise at 100–300 Hz. For these reasons it was decided to adopt the usage of DC current and the anodal active electrode on the anterior tongue.

Electrogustometric detection thresholds were found to be highly reproducible (correlation coefficient = 0.9998).

#### Normal subjects

Median ages for males and females were similar at 39 years. Of males 39% and of females 26.3% smoked. Using the Chi squared test, this difference approached significance ( $0.05 < p < 0.1$ ). A Mann Whitney U test revealed a significant difference for number of cigarettes smoked when males were compared with females ( $p < 0.05$ ). In those who smoked the mean number of cigarettes smoked for males was 19 per day, and 14 per day for females.

Analysis of tastes thresholds revealed a high correlation between taste on right and left sides of the tongue. (Correlation coefficient = 0.9754), with the inter-side difference never exceeding 25% of the higher value. Straight analysis revealed a highly significant correlation between age and taste threshold

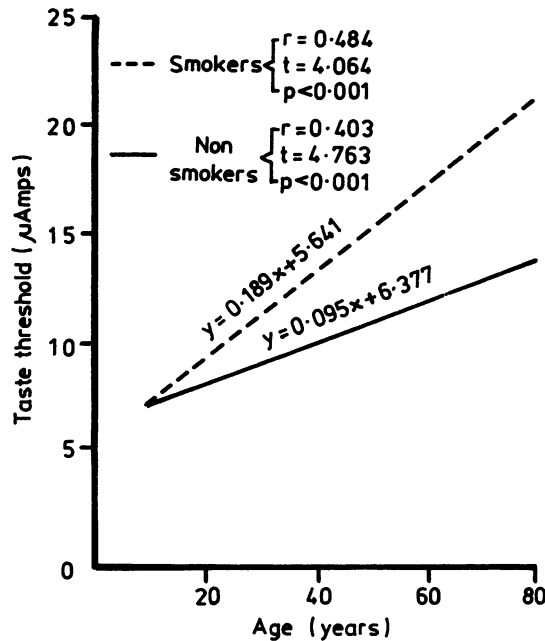


Fig 3 Regression lines of taste threshold in ( $\mu A$ ) with age for smokers and non-smokers.

( $p < 0.001$ ), with the threshold increasing with age. After excluding patients under the age of 20 years there was also a strong correlation ( $p < 0.005$ ) between number of cigarettes smoked and increase in taste threshold. A Mann Whitney U test for taste threshold demonstrated a significant sex difference ( $p < 0.005$ ), males having a higher threshold. Although the age distribution in the two sexes was comparable, the percentage of individuals who smoked and the number of cigarettes smoked was different. This could be responsible for the apparent difference in taste threshold and therefore partial correlations were performed.

When taste threshold was studied in comparison with age and taking into account smoking and potential sex difference, there was still found to be a significant increase in threshold with age (fig 3). Taste was compared with quantity smoked, corrected for age and sex, and there was a significant correlation ( $p < 0.001$ ) between number of cigarettes smoked and elevations of taste threshold. However, no significant difference was noted between taste threshold and sex once smoking was taken into account ( $p > 0.1$ ). The highest threshold value encountered, regardless of age at smoking habit, was  $40 \mu A$  and this, therefore might be regarded as the upper limit of normal.

Measuring the pH at different currents with the anodal active electrode and then the cathodal active

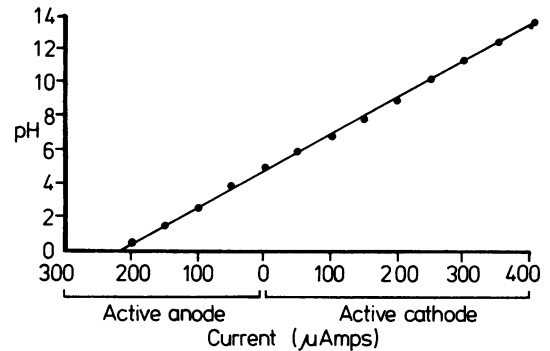


Fig 4 Relationship between current and pH at the active electrode, in a  $0.01 M$  solution of potassium chloride at  $20^\circ C$ .

electrode a linear relationship between pH and current became evident (fig 4).

#### Patients

Twenty patients with trigeminal neuralgia were studied of whom seven had multiple sclerosis (table 1). The mean age at onset of "idiopathic" trigeminal neuralgia was 53 years and in patients with multiple sclerosis 38 years. Twelve patients had right and 10 had left mandibular trigger points. There were two patients with bilateral trigeminal neuralgia, both of whom were diagnosed as suffering from multiple sclerosis on clinical grounds, abnormal pattern reversal visual evoked responses (VERs) and the presence of oligoclonal bands in the cerebrospinal fluids.

In the patients treated by glycerol injection four had abnormal electrogustometric detection thresholds on the affected side before surgery. Of these, three had definite multiple sclerosis and three (WA, JY and SR) had undergone previous attempts at pain relief either by glycerol injection or thermocoagulation. In one case (SR) there was a deterioration in electrogustometric recording on the affected side after surgery. In this case and in four others (MM, ES, RB and RP) hypalgesia was present post-operatively in the mandibular division of the trigeminal nerve. In all patients with elevated electrogustometric detection thresholds, taste was also diminished on the affected side by chemical testing. In those with normal electrogustometric recordings, chemical taste did not reveal any inter side difference. However, many patients while recording a definite taste consistently confused acid for bitter. A few misinterpreted 40% saccharin as bitter. There were no significant quality specific taste changes in patients with multiple sclerosis.

No patients with trigeminal neuralgia treated by thermocoagulation showed an abnormality in their taste by chemical or electrogustometric testing before

Table 1 Trigeminal neuralgia

	Patient	Age (yr)	Sex	Length of history (yr)	Pre		Post	
					R	L ( $\mu A$ )	R	L
Glycerol injection Idiopathic	SR	54	M	4	20	200*	30	400*
	RP	59	M	9	12*	12	12*	12
	DR	60	M	1	10*	10	10*	10
	ES	68	F	10	8	10*	10	10*
	MM	77	F	10	20	17*	18	17*
Multiple sclerosis	JY	29	M	5	35	400*	32	400*
	ST	41	F	6	8*	8*	8*	8*
	IM	44	F	1	12*	13	10*	11
	RB	48	F	8	120*	29	110*	26
	JR	49	M	10	8*	9*	9*	9*
	WA	54	M	15	10	400*	10	378*
	PR	59	F	10	12*	12	12*	13
	WB	63	M	1	10*	10	10	10
Coagulation	AMcC	72	F	3	25	20*	20	20*
	MSc	74	F	8	7	7*	7	7*
Decompression	MP	33	M	8	7*	7	7*	7
	MSt	48	F	2	10*	16	48*	16
	GH	56	F	20	16	16*	16	16*
Section	EMcN	59	F	8	15*	15	16*	15
	MD	63	F	10	8*	8	40*	8

\*Affected side.

or after surgery, and all had hypalgesia in the lower face on the affected side following surgery.

In the three patients treated by microvascular decompression one had a moderate diminution of taste on the affected side post-operatively. This was confirmed by post-operative chemical testing where there appeared to be a complete loss of salt and acid taste but saccharin was retained at concentrations of 10% and 40% and quinine hydrochloride at 0.5% and 1%. The reason for this is difficult to explain as there was no apparent damage to the trigeminal nerve or chorda tympani during the operation. None of these patients complained of loss of sensation in the trigeminal division post-operatively.

Partial section of the trigeminal nerve, at its entry to the pons, was performed in two cases. In one (EMcN) the lower third of the nerve was divided and in the other (MD) 50% root section was performed as it entered the pons. Post-operatively both were found to have loss of sensation over the lower face of the affected side and one (MD) complained of diminution of taste on the right side of her tongue. A significant

asymmetry was noted on electrogustometric testing in this case. Olfaction was normal in all cases.

#### Idiopathic trigeminal neuropathy

Five patients with idiopathic trigeminal neuropathy were studied (table 2). The left trigeminal nerve was affected in three patients and the right in two. All three divisions on the affected side were involved in two cases, and the mandibular and maxillary divisions only in the others. None has oculomotor nerve palsy. Two patients (RD and AMcG) had definite abnormalities of taste on electrogustometric detection threshold estimation and complete ageusia on the affected side by chemical tests. The patient GMcD, was able to identify chemical tastes except bitter at all concentrations although he felt that the taste was "stronger" on the non-affected side. Saccharin was interpreted as bitter at all concentrations by RM, and he had also lost his sense of smell since undergoing nasal polypectomies two years previously. All subjects apart from this patient had a normal sense of smell.

Table 2 Idiopathic sensory trigeminal neuropathy

Patient	Age (yr)	Sex	Length of history (yr)	R	L
GMcD	54	F	6	7	11*
RD	58	F	10	120*	29
WL	58	F	2	10	10*
RM	64	M	2	13*	13
AMcG	66	F	4	23	102*

\*Affected side.

#### Discussion

There are two theories concerning the basis of electrical taste. The first is that of an electrolytic-chemical stimulation of the taste receptors and the second is a direct effect of the current on membrane potential of either nerve fibres or taste cells. These hypotheses have been reviewed in some detail by Bujas.<sup>25</sup> From the micropipette analyses it would appear that there is an accumulation of hydrogen ions around the anode

as a consequence of electrolysis of constituents of saliva and a sour acid taste is produced. When the electrodes are reversed a less easily defined alkaline taste is produced at a higher threshold. The decrease found in intensity of taste with increase in frequency of alternating current supports the findings of other authors<sup>26 27</sup> and would be more in keeping with the electrolytic-chemical hypothesis. It is clear that only taste fibres are stimulated at currents less than approximately 300  $\mu$ A. Higher levels of current may stimulate pain or temperature fibres directly giving a tingling or burning sensation distinct from the sour taste of anodal or bitter/soapy taste of cathodal stimulation. However, no response could be elicited in other areas of the oral mucosa using currents greater than 1 mA. In patients with ageusia due to disorders affecting the chorda tympani or nervus intermedius with normal sensation to pain or temperature, electrogustometric recordings are generally over 300  $\mu$ A.<sup>3 4 21 25</sup>

A sex difference in taste threshold has been reported,<sup>28 29</sup> although this finding has not been corroborated by other workers, using both electrogustometry<sup>3</sup> and chemical stimulation.<sup>30 31</sup> The present study confirms an apparent sex difference but this is wholly accounted for by smoking habits. Hence there is no intrinsic sex difference in taste threshold and the phenomenon is a secondary feature.

A significant increase in detection threshold was found with age and this probably relates to the decrease in number of papillae and number of taste buds per papilla with ageing. Whether these changes are primary or secondary to nerve fibre loss is, however, uncertain. The findings are in agreement with electrogustometric recordings<sup>3 32</sup> and parallel the results of chemical tests for taste threshold in the elderly.<sup>33 34</sup>

The data show a significant elevation in taste threshold with age in both smokers and non-smokers. Whereas in young people there is a negligible difference due to smoking, this becomes more evident with increasing age (fig 3). As there was no obvious difference in the number of cigarettes smoked between age groups, this suggests that duration of smoking is a relevant factor.

Various authors have suggested a higher threshold for bitter taste in smokers<sup>35 36</sup> and, more recently, a difference in salt taste.<sup>34</sup> The threshold rise with smoking is more marked than with age. Kaplan *et al*<sup>37</sup> felt that the elevated threshold with age was only seen in smokers. However, in their study fewer than 10% of male non-smokers were over 40 years of age and the upper limit of the age range was 55 years. This may not have been an adequate sample to fully analyse age and smoking effects.

Four basic tastes are classically described: sweet,

salt, sour and bitter. In clinical practice, taste is tested by carefully applying drops of sodium chloride (2.5%, 7.5% and 15%), citric acid (1%, 5%, 10%), saccharin (1%, 10%, 40%) and quinine hydrochloride (0.075%, 0.5%, 1%) on to the anterior two-thirds of the tongue on either side. This "drop technique" has several major disadvantages. It is laborious for subject and examiner, and the threshold will vary depending on the precise volume and location of the drop applied. If performed with care, however, each side of the tongue can be tested independently unlike the "sipping technique" where various concentrations of test solutions are sipped and then discarded. This latter method requires the subject to identify the taste, and whether the solution is stronger or weaker than the previous one. The "sipping technique" is quicker and easier to perform although the solution will stimulate taste buds bilaterally on the tongue, soft and hard palate and pharynx. It is therefore unlikely to identify lateralised lesions affecting the taste pathways. Taste thresholds are subject to the phenomenon of adaptation and the order of presentation of solutions may well be important. Often water "rinses" are used between stimuli.

Unfortunately there are no standard tests that are universally accepted. There are two types of taste threshold. The "detection threshold" is where the subject is aware of a taste but unable to identify it. The "recognition threshold" is the concentration at which the patient can identify the solution. The latter threshold is usually higher. This study has only assessed the detection threshold and may account for the marked discrepancy in values when compared with threshold results of Krarup.<sup>3</sup>

As chemical tests strive to become more accurate they also become complex and procedures such as multi-dimensional scaling of similarity judgments<sup>9</sup> and determination of skin conductance require trained personnel to record and interpret results. The battery operated electrogustometer described is a convenient method of testing patients suspected of having a taste disorder. Each side of the tongue and, if necessary, the posterior third of the tongue can be examined. As the subject is unaware when the stimuli will present, the test is more objective. Gustatory reaction times to taste solutions and electrical taste have been studied and found to be less than 2 seconds.<sup>38 39</sup>

The electrogustometer has many advantages over chemical tests to assess taste. It is simpler and less time consuming to patient and examiner. Localisation of stimuli is more accurate and a reproducible digital display recording is obtained. Early lateralised lesions affecting taste can be demonstrated such as in patients with Bell's palsy,<sup>40 41</sup> and tumours at the cerebello-pontine angle.<sup>42</sup> It will be of considerable

interest not only in testing the effects of drugs on taste but also in identifying lateralised diseases affecting taste pathways.

Electrogustometric assessment of taste detection threshold was much quicker and easier to perform than chemical analysis of taste with a numerically accurate recording being obtained. The results of both forms of testing were equivalent in that patients with unilateral loss of taste noted a difference between sides by both techniques although some recorded citric acid as bitter or misinterpreted an occasional taste making results more difficult to assess.

Trigeminal neuralgia is a clinical diagnosis characterised by severe paroxysms of tearing or lancinating pain commonly precipitated by touch in certain trigger zones and usually confined to one division of the trigeminal nerve. Typically there are no abnormal clinical neurological signs. The pathogenesis is uncertain but both a peripheral cause and central mechanism have been postulated, with chronic irritation of the nerve causing segmental inhibition of the trigeminal nucleus and ectopic action potentials in the trigeminal nerve has been suggested.<sup>43</sup> The responsible lesion is usually considered to be peripherally situated within a few millimetres of the pons, most commonly an aberrant vessel causing compression of the trigeminal nerve. The exception to this peripheral localisation of a lesion in trigeminal neuralgia is multiple sclerosis.<sup>44</sup> This is the only disease of the CNS which is definitely associated with trigeminal neuralgia:<sup>19</sup> a plaque of demyelination has been found in the trigeminal root entry zone in these cases.<sup>45</sup> The site of damage is therefore thought to be accurately localised in idiopathic trigeminal neuralgia and in trigeminal neuralgia secondary to multiple sclerosis. Diminished taste and quality specific taste changes are well recorded in multiple sclerosis without accompanying trigeminal neuralgia.<sup>46 47</sup>

In the cases of trigeminal neuralgia studied, seven had multiple sclerosis and of these, three had diminished taste acuity on the ipsilateral side. This may have been related to previous attempts at surgical treatment in two of the three cases with local damage to the gasserian ganglion or alternatively may be the result of "central" demyelination. If the latter is the case then the plaque must involve both gustatory fibres and the root entry zone.

In the two cases where a definite and significant difference was noted in taste detection threshold after surgical procedure, both involved posterior fossa exploration with mobilisation of the nerve and in one 50% partial root section of the lateral part of the trigeminal nerve as it enters the pons. No patient developed facial weakness or hearing loss after surgery and it is unlikely that the chorda tympani or nervus intermedius would be significantly traumatised during

such procedures. Several authors have recorded loss of taste following partial root section<sup>20 48</sup> or alcohol injection into the foramen ovale<sup>49</sup> and concluded that there was an alternative taste pathway through the trigeminal nerve. This seems to be supported by occasional findings of preserved taste following chorda tympani section.<sup>50</sup> Proponents of the chorda tympani as the only taste pathway suggest that either the chorda tympani or nervus intermedius is damaged during procedures for treatment of trigeminal neuralgia.<sup>21 51 52</sup> Suggested mechanisms behind presumptive damage include trophic degeneration of the lingual nerve following root section with associated degeneration of the taste fibres or accidental fracture of the temporal bone during craniectomy. It is certainly more difficult to dismiss the loss of taste associated with trigeminal neuropathies.<sup>53 54</sup>

The aetiology of trigeminal sensory neuropathy is uncertain but recognised associations exist with connective tissue disease,<sup>55</sup> viral infections<sup>56</sup> trauma and tumours. The sensory loss is of a peripheral distribution and may be associated with decreased taste sensation.<sup>53 54</sup> Two of the cases had markedly abnormal electrogustometric detection thresholds on the ipsilateral side. Unless this is due to part of a more widespread cranial neuropathy, which would seem unlikely, a common pathway via the trigeminal nerve for taste and sensation in some individuals must be postulated.

The observations presented here of ipsilateral loss of taste in some patients with trigeminal neuralgia and trigeminal neuropathy support the findings of several authors<sup>19 20 21 50 53 54</sup> of the possible existence of an alternative or accessory taste pathway that relays through the gasserian ganglion and root entry zone. Alternatively, the possibility exists in multiple sclerosis of demyelination which involves taste fibres in the pons.

Anatomical studies of the gustatory system in animals<sup>57 58</sup> reveal that fibres from the lingual nerve terminate in the lateral solitary nucleus and this projection overlaps with projections from the chorda tympani, adjacent to the trigeminal nerve root entry zone. A plaque of demyelination in this area may result in unilateral loss of taste and could generate pain of trigeminal neuralgia.

The pathways subserving taste sensation require a thorough reevaluation. This has been hindered, in the past, by the lack of a simple reproducible method of testing taste. The use of electrogustometry should provide a reliable objective recording of gustatory detection thresholds, which will simplify the clinical assessment of taste.

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